Fuel Economy

Fuel Economy Test Description

Procedures for the fuel economy tests were based on SAE Standard J1082*, "Fuel Economy Measurement Road Test Procedure." Technicians took the following measurements:

- Urban cycle fuel economy, which simulates driving conditions on streets at the centers of large cities.
- 70-mph interstate cycle fuel economy, which simulates driving conditions on limited-access divided highways.
- 150-mile combined cycle fuel economy, which simulates the driving conditions of both the urban and interstate cycles by repeating the two cycles every 7.5 miles for a total of 150 miles.

The ballast condition for all tests and configurations was unloaded vehicle weight plus 300 lb.

Fuel Economy Test Preparations

In addition to the tasks indicated in General Test Preparations, the following pre-test tasks were performed:

- The tires were measured to confirm that the treads had worn no more than 25%.
- The tire pressures were set to placard values.
- The air conditioning compressor clutches were deactivated.
- The rear axles' drum brakes were adjusted such that there was no drag when the brake pedals were released. Also, it was confirmed that there was no excessive drag at the front axles' disc brakes.
- Gravimetric fuel economy measurement systems were installed.
- Fifth wheel instrumentation was installed for the measurement of cycle run time and distance.
- U-tube decelerometers were installed for use by the fuel economy test drivers.
- The vehicles were weighted to the indicated ballast condition.
- Vehicle specification and check list sheets based on SAE J1082 forms were completed.

Fuel Economy Test Procedures

The fuel economy tests were conducted on a 7.5-mile oval, multi-lane concrete roadway with two straight sections (each approximately 2 miles in length) and two 180° turns (each with a radius of 2400 ft). The straight sections have a consistent grade of 0.2%. The plan view and elevation of the oval are symmetrical about a line, which bisects the two turns.

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Immediately prior to testing, the tire pressures were re-checked and adjusted if necessary. The vehicles were also weighed with the driver, instrumentation, and ballast in place. Final weight adjustments were made, and technicians recorded test weights.

When testing began, the vehicles were driven for a half-hour on the 7.5-mile oval to bring the drivetrain and tires up to normal operating temperatures. Immediately after completing the warm-up procedure, the fuel economy tests began. Warm-up drives were completed before every fuel economy test session.

Each fuel economy cycle was completed with both vehicles operating on the oval approximately 3 minutes apart. In this way, the vehicles experienced the same weather conditions for each test run. Hazard flashers and headlights were switched on during all tests to allow drivers of other test units to identify the fuel economy vehicles and avoid interfering with the fuel economy driving procedure.

Gravimetric analysis was used to determine the amount of fuel each vehicle consumed during each test run. With the gravimetric fuel economy measurement system, a removable gravimetric tank with fuel pump is valved into the vehicle's fuel system at the start of each measurement period and valved out at the end of the period. Time and distance measurement using fifth wheel instrumentation began and ended simultaneously with the switch to and from the gravimetric system. The removable tanks were weighed before and after each run and technicians recorded distance measurements.

The weights of consumed fuel were calculated to the nearest gram and converted to pounds. The specific gravities of the fuels were measured and multiplied by the specific weight of water and the weights of fuel consumed to produce the volumes of fuel consumed. At the end of each test session, the fifth wheel calibrations were measured to produce a correction factor, which was applied to the distances indicated by the instrumentation. The observed fuel economies were then calculated. SAE 1082 provides correction factor formulas for ambient temperature and barometric pressure. These correction factors were applied to the observed fuel economy results of the urban and interstate cycles. No temperature and barometric corrections were applied to the 150-mile combined cycle results.

Fuel Economy for Alcohol Fuels

The fuel economy test results for this project are reported on a volumetric basis. Alcohol fuels, however, have a lower volumetric energy content than gasoline. The energy content of the RF-A test fuel used in this program is 114,909 Btu/gal; the energy content of the E85 is 83,020 Btu/gal. The E85 test fuel used, then, has a volumetric energy content approximately 72% that of the gasoline test fuel. Because of this difference, fuel economy for alcohol vehicles is often expressed as miles per equivalent gallon (mpeg). The mpeg measurement gives an estimate of how far the vehicle can travel on an amount of alcohol fuel that has the same energy content as a gallon of gasoline. For the test fuels used in this program, it takes 1.38 gallons of E85 to travel the same distance as 1 gallon of RF-A.

Urban Cycle

The 2.0-mile urban cycle consists of starts, stops, speed changes, and steady speeds. Some stops include a 15-s idle period. Accelerations are 5 to 7 ft/s^2 and all decelerations are 4 ft/s^2. Steady speeds of 15, 20, 25, and 30 mph are maintained for less than 0.2 miles. The cycle begins and ends with the vehicle at rest. (View the Urban Fuel Economy Cycle Graph.)

The urban cycle was run between two points on the 7.5-mile oval symmetrical about a line that bisects the oval's two turns such that the cycle start and end points were at the same elevation. This complies with the elevation change restrictions of J1082.

At a minimum four urban cycle runs were completed for each configuration with the two test drivers switching vehicles between runs. For each vehicle, the data from the first two runs were combined - as were the data from the last two runs - to average operational differences between the two drivers. The results of the two combined runs were then compared and tested for variation. The data were accepted if the variation was no more than 2%. If the data were not acceptable, additional runs were completed until two consecutive combined runs met the 2% requirement.

Ambient requirements for the urban cycle are temperatures of 32 to 90° F and wind speeds averaging no more than 15 mph with gusts no more than 20 mph.

The vehicles were operated with the windows closed, the climate control fan operating on its lowest speed, and the AM/FM radio switched on. Low-beam headlights and hazard flashers were switched on. All other switchable electrical equipment was turned off.

70-mph Interstate Cycle

The 4.7-mile interstate cycle consists of steady 70-mph operation with accelerations to 75 mph followed by decelerations to 65 mph and then back to 70 mph once per mile. All

accelerations and decelerations are 1 ft/s^2. The cycle begins and ends with the vehicle traveling at 70 mph. (View the 70-mph Interstate Fuel Economy Cycle Graph.)

The interstate cycle was run between two points on the 7.5-mile oval. The oval is symmetrical about a line that bisects the two turns such that the cycle start and end points are at the same elevation, complying with the elevation change restrictions of J1082.

A minimum of four interstate cycle runs were completed for each configuration with the two test drivers switching vehicles between runs. For each vehicle, the data from the first two runs were combined - as were the data from the last two runs - to average operational differences between the two drivers. The results of the two combined runs were then compared and tested for variation. The data were accepted if the variation was no more than 2%. If the data were not acceptable, additional runs were completed until two consecutive combined runs met the 2% requirement.

Ambient requirements for the interstate cycle are temperatures of 32 to 90° F and wind speeds averaging no more than 10 mph with gusts no more than 15 mph.

The vehicles were operated with the windows closed, the climate control fan operating on its lowest speed, and the AM/FM radio switched on. Low-beam headlights and hazard flashers were switched on. All other switchable electrical equipment was turned off.

150-Mile Combined Cycle

The 150-mile combined cycle included alternate repetitions of the urban and interstate driving cycles described above. The two sub-cycle driving procedures were as described above except that the fuel measurement periods continued through transitions between the two. The transitions were 0.4 miles in length and simulated typical accelerations and decelerations on limited-access highway entrance and exit ramps. The combined length of one each of the urban and interstate sub-cycles and the two transitions was 7.5 miles, which equaled the length of the oval. The 150-mile combined cycle was split into four sections of 37.5 miles each, allowing for test driver safety breaks and for refueling and weighing of the gravimetric tanks. While the drivers took their breaks, engineering staff members weighed and refueled the tanks and kept the vehicles at operating temperatures by driving them using fuel from the vehicles' stock tanks.

The two test drivers drove each vehicle for one-half of the 150-mile cycle, switching vehicles at the halfway point. Because of the length of the test and because the A/C compressor clutches were deactivated, the vehicles were operated with the driver's window opened slightly and the climate control fan set on the intermediate speed to allow for driver comfort. Low-beam headlights and hazard flashers were switched on. The AM/FM radios were switched on and all other switchable electrical equipment was turned off.

The ambient requirements for the combined cycle were the same as the more stringent

interstate cycle requirements. The four 37.5-mile sections were not necessarily completed in the same day. This allowed the tests to be completed in a timely manner without having to wait for 8 h windows of acceptable ambient conditions.

Although fuel economy was calculated and reported for each 37.5-mile section, the final result was the overall fuel economy for the 150-mile test cycle.

* Society of Automotive Engineers Surface Vehicle Standard. J1082, "Fuel Economy Measurement Road Test Procedure," Issued 1974-04, Revised 1995-06.

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